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Path forward for dealing with uncertainties in the radiologic source term (RST) for Pahute Mesa for the UGTA activity

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The radionuclide source term (RST) for the NNSS is the radionuclide amounts, either in Curies (Ci) or number of atoms, that existed from underground nuclear testing as of Sept. 23, 1992, the day of the last U.S. underground nuclear test (Bowen et al., 1992). (Note that this inventory was recently updated to consider radioactivity decay through Sept. 20, 2012 [Finnegan et al. 2016]). The RST is a major input for calculating the hydrologic source term (HST), which is the fraction of the RST that is accessible to groundwater after partitioning between groundwater, melt-glass and gas has been accounted for. The RST inventory was calculated for each of the 5 major testing areas: (1) Area 19 of Pahute Mesa; (2) Area 20 of Pahute Mesa; (3) Areas 12, 16, 18 and 30, which together constitute the Rainier Mesa/Shoshone Mountain CAU; (4) Areas 2,3,4, 6,7,8,9,10 and 15, which together constitute the Yucca Flat/Climax Mine CAU; and (5) Areas 5 and 11, which together constitute the Frenchman Flat CAU. The radionuclide inventory in the Yucca Flat/Climax Mine CAU was further broken down to include tests 100 m or more above the water table, as defined in DOE (1997), and tests that were either below or within 100 m of the water table. In an unclassified setting, the test-specific RST is estimated from the unclassified inventory for that particular CAU in Bowen et al. (2001) using the ratio of the maximum of the announced yield range of the test relative to the sum of the maximum announced yield ranges of all tests within the CAU. Thus, the fraction of the inventory associated with a given nuclear test is proportional to the maximum of the announced yield ranges as listed in NNSA/NFO (2015).

The RST inventory published in Bowen et al. (2001) is based on classified test-specific data, which was then summed with classified inventory estimates of other tests from the same area so as not to reveal information specific to any individual test. Often, tests within an area underwent significantly different degrees of post-test characterization, with some tests undergoing extensive drill-backs and core sampling, and others lacking post-test characterization. The tests and individual radionuclides that lacked characterization were estimated through modeling of the device performance, based on calibration of the models to measurements of the same device at better characterized locations. The radionuclide inventory is thus based both on direct measurements and model-based estimates extrapolated from tests that used similar devices.

As currently implemented in UGTA groundwater flow and transport models, the test specific RST estimated from Bowen et al. (2001) CAU inventory is considered uncertain, with the specific radionuclide uncertainty dependent on the radionuclide category:

Fission products:	~ 10 to 30 % for most of the fission products
Unspent fuel materials:	~ 20 % or better
Fuel activation products:	~ 50 % or better
Residual tritium:	~ 300% or better
Activation products:	~ a factor of 10

Bowen et al. (2001) describes which radionuclides reside in which radionuclide category and the basis for the uncertainty estimates provided above. The uncertainty estimates consider many factors, but in the end, the uncertainties listed above are highly generalized and strongly depended on expert judgement. Uncertainties of individual radionuclides within a category can vary widely, and uncertainties for the same radionuclide can vary widely between tests, depending on the data from post-test characterization, device type, and device performance.

In assessing whether it is necessary, or even feasible, to reduce the uncertainties in the RST inventory for Areas 19 and 20 at Pahute Mesa, we considered the following:

- The stated uncertainties in the RST inventory estimates are qualitative at best, and can vary widely between tests and between individual radionuclides within each radionuclide category.
- Reducing uncertainties in the RST would be a major undertaking, requiring a re-examination of all of the classified reports for 82 tests and 43 radionuclides of concern. Even then, there would be no guarantee the Area 19 and 20 RST inventory uncertainties for many radionuclides could be defensibly reduced.
- Even with their relatively high errors, the activation products, device or geology, represent an insignificant portion of the RST. Furthermore, due to the limited historical or modern analysis of activation products, it would be impossible to further constrain the error associated with them.
- In an unclassified setting in which most under the UGTA activity is done, the test-specific inventory is approximated based on the maximum of the announced yield range (which can vary almost an order of magnitude for many tests, e.g. 20-200 kt) making marginal reductions in RST uncertainty inconsequential.
- Groundwater sampling of radionuclides downgradient from large-yield tests has indicated that ^{3}H is the primary radionuclide of concern from a regulatory perspective, making uncertainties in other radionuclides in the RST of secondary interest.
- The uncertainty in the RST of individual test appears to be small compared with uncertainties in the relationship between the RST and HST, based on the low levels of other radionuclides in water samples with high ^{3}H concentrations where other radionuclides should also have elevated concentrations.

In conclusion, it doesn't appear to be feasible to reduce uncertainty in the RST inventory for Areas 19 and 20 with the resources available, given that the original Bowen et al. (2001) report involved thirteen radiochemists, many of whom actively participated in the classified work on which the unclassified inventory was based. Fortunately, from groundwater sampling, it appears that ^{3}H is the main radionuclide of concern from a regulatory perspective and that other factors such as the use of the maximum of the announced yield range and uncertainty in the conversion of the RST to an HST will likely overwhelm any incremental reduction in the uncertainty in the RST.

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